

What is claimed is:

1. A shaped solid dosimeter device fabricated from a transparent or translucent polymer and one or more reporter molecules dispersed within said device.
2. The device of claim 1 wherein said transparent or translucent polymer is  
5 an optical plastic.
3. The device of claim 2 wherein said optical plastic is selected from the group consisting of acrylic, polystyrene, polyacetal, cyclic olefin copolymer, polycarbonate, epoxy resin, silicone, siloxane, polymethylpentene, polyester, polysulfone, and polyurethane, copolymers and blends thereof.
- 10 4. The device of claim 1 wherein the one or more reporters are selected from the group consisting of spiropyrans, spirothiopyrans, spironaphthooxazines, spirobenzopyrans, spiroindolobenzopyrans, chromenes, 2,2,-dichlorchromenes, leuco quinines, anthroquinone dyes, thiazine leuco dyes, oxazine leuco dyes, phenazine leuco dyes, monoarylmethane phthalides, diarylmethane phthalides, triarylmethane phthalides,  
15 monoheterocyclic phthalides, bisheterocyclic phthalides, alkenylphthalides, bridged phthalides, bisphthalides, diarylmethanes, triarylmethanes, triarylmethane lactones, fluoran leuco dyes, and tetrazolium salts.
5. The device of claim 1 wherein the one or more reporters are spiropyran, thiazine, oxazine, phenazine, phthalide, tetrazolium salt, diacetylene, triarylmethane,  
20 triarylmethane lactone, or fluoran.
6. The device of claim 1 wherein the reporter is triarylmethane.
7. The device of claim 1 wherein the reporter compound is triarylmethane lactone.
8. The device of claim 1 wherein the reporter compound is fluoran.
- 25 9. The device of claim 1 further comprising one or more activators dispersed within said device.
10. The device of claim 9 wherein the one or more activators are selected from the group consisting of  $\alpha$ -hydroxy alkylphenones, acyl phosphine oxides, O-acyl- $\alpha$ -oximinoketones, organic peroxides, phenylgyoxylates, desylarylsulfides, phenyl  
30 phenacylsulfides, metallocene derivatives, transition-metal carbonyls,  $\alpha$ -amino acids, halogenated hydrocarbons, polyhalogenated hydrocarbons, alkoxyamines, azoalkane

derivatives, diazonium salts, diaryliodonium salts, triarylsulfonium salts, dialkylphenacylsulfonium salts, ferrocenium salts,  $\alpha$ -sulfonyloxyketones, and silyl benzyl ethers, benzoin ethyl ether; benzoin isopropyl ether; benzoin butyl ethers (isomeric); benzoin isobutyl ether; benzildimethyl ketal; 2,2-diethoxy-1,2-diphenylethanone; 1,1-  
 5 diethoxyacetophenone; 1,1-di(n-butoxy)acetophenone; 1-hydroxy-cyclohexyl-phenyl ketone; 2-hydroxy-2-methyl-1-phenyl-propan-1-one; 1-[4-(2-hydroxyethoxy)phenyl]-2-hydroxy-2-methyl-propan-1-one; benzophenone; 2-methyl-1-[4-(methylthio)phenyl]-2-morpholino-propane-1-one; 2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)-butan-1-one; 2,4,6-trimethylbenzoyl-diphenylphosphine oxide; 2,4,6-trimethylbenzoyl-  
 10 phenylphosphinic ethyl ester; bis(2,4,6-trimethylbenzoyl)-phenylphosphine oxide; bis(2,6-dimethoxybenzoyl)-2,4,4-trimethylpentylphosphine oxide; 2,2,2-trichloro-1-[4-(1,1-dimethyl)phenyl]-ethanone; 2,2-dichloro-1-(4-phenoxyphenyl)-ethanone; 4,4'-bis(chloromethyl)benzophenone; phenyl tribromomethylsulfone; methyl benzoyl formate; 2,4,6-trimethylbenzophenone; 4-methylbenzophenone; 4-chlorobenzophenone;  
 15 4-(4-methylphenylthio)benzophenone; 3,3'-dimethyl-4-methoxybenzophenone; methyl 2-benzoylbenzoate; 4-phenylbenzophenone; 4,4'-bis(dimethylamino)benzophenone; 4,4'-bis(diethylamino)benzophenone; 2-chlorothioxanthone; 4-chlorothioxanthone; 2-isopropylthioxanthone; 4-isopropylthioxanthone; 2,4-dimethylthioxanthone; 2,4-diethoxythioxanthone; 1-chloro-4-propoxythioxanthone; benzil; 1,7,7-trimethyl-  
 20 bicyclo[2.2.1]heptane-2,3-dione; 2-ethylanthraquinone; 4-benzoyl-N,N,N-trimethylbenzene methaminium chloride; 2-hydroxy-3-(4-benzoylphenoxy)-N,N,N-trimethyl-1-propaniminium chloride; 2-hydroxy-3-(3,4-dimethyl-9-oxo-9H-thioxanthone-2-yloxy)-N,N,N-trimethyl propaniminium chloride; 4-(13-acryloyl-1,4,7,10,13-pentaoxatridecyl)benzophenone; 4-benzoyl-N,N-dimethyl-N-[2-(1-oxo-2-  
 25 propenyl)oxy]ethyl benzenemethaminium chloride; methyldiethanolamine; triethanolamine; ethyl 4-dimethylaminobenzoate; 2-n-butoxyethyl 4-(dimethylamino)benzoate; isoamyl 4-dimethylaminobenzoate; 2-(dimethylamino)ethyl benzoate; tetrachloroethane; carbon tetrachloride; chloroform; dichloromethane; methylene chloride; 1,4-dichloro-2-butene; 2,2'-azobis(isobutyronitrile); 4,4'-azobis(4-cyanovaleric acid); 1,1'-azobis(cyclohexanecarbonitrile); 2,2'-azobis(2-methylpropane),  
 30 1,1-dichloropropane; 1,2-dichloropropane; 1,3-dichloropropane; 2,4,5-trichloroimidazole;

2,2-dichloropropane; 1,2-dichlorobutane; 1,3-dichlorobutane; 1,4-dichlorobutane; 1,1,1-trichloroethane; 1,2,2-trichloroethane; 1,2,3-trichloropropane; 1,1,1,2-tetrachloroethane; 1,1,2,2-tetrachloroethane; bromoform; methylene bromide; dibromomethane; 1,1-dibromo-2,2-bis(chloromethyl)cyclopropane; 1,2-dibromobutane; 1,3-dibromobutane;  
 5 1,4-dibromobutane; 2,3-dibromobutane; 1,4-dibromo-2,3-butanedione; 1,4-dibromo-2-butene; 1-bromo-4-chlorobutane; 1-bromo-2-chloroethane; 1-bromo-6-chlorohexane; bromochloromethane; 1-bromo-5-chloropentane; 1-bromo-3-chloropropane; 2-bromo-1-chloropropane; 1,1,2-tribromoethane; 2,4,5-tribromoimidazole; 1,2,3-tribromopropane; bromodichloromethane; chlorodibromomethane;  $\alpha$ -(trichloromethyl)benzyl acetate;  
 10 diphenyliodonium hexafluorophosphate; 4-methylphenyl-4'-isobutryl iodonium hexafluorophosphate; and ferrocene.

11. The device of claim 1 wherein the one or more activators are an organic peroxide, a halogenated hydrocarbon, or an azo compound.

12. The device of claim 1 wherein the activator is a halogenated hydrocarbon.

15 13. The device of claim 1 wherein the activator is selected from the group consisting of chloroform, dichloromethane, carbon tetrachloride, trichloroethane, and tetrachloroethane.

14. The device of claim 1 further comprising a UV stabilizer dispersed within the device selected from the group consisting of benzophenones, phenolics,  
 20 thiopropionates, trialkyl phosphites, triaryl phosphites, benzoates, benzotriazoles, cyanoacrylates, organonickel compounds, organozinc compounds, diphenyl acrylates, cinnamates, and hindered amines.

15. The device of claim 1 further comprising a UV stabilizer dispersed within the device selected from the group consisting of benzotriazoles and hindered amines.

25 16. The device of claim 2 wherein the optical plastic is a polyurethane formed by a chemical reaction of one or more isocyanate-containing prepolymers and one or more polyol prepolymers in the presence of one or more polymerization-promoting catalysts.

30 17. The device of claim 16 wherein said chemical reaction takes place within a mold under controlled conditions of temperature, pressure, and duration of reaction.

18. The device of claim 16 wherein the isocyanate-containing prepolymer comprising 4,4'-methylene bis(cyclohexyl isocyanate) or 1,6-hexamethylene diisocyanate or a mixture thereof and the polyol prepolymer comprising one or more of polyether polyol, polycarbonate polyol, or polyester polyol.
- 5 19. The device of claim 16 wherein the isocyanate-containing prepolymer comprises 4,4'-methylene bis(cyclohexyl isocyanate).
20. The device of claim 16 wherein the isocyanate-containing prepolymer comprises 1,6-hexamethylene diisocyanate.
21. The device of claim 16 wherein the polyol is a polyether polyol.
- 10 22. The device of claim 16 wherein the polyol is a polyester polyol.
23. The device of claim 16 wherein the polymerization-promoting catalyst is selected from the group consisting of tertiary amine, organometallic, metal salt of a carboxylic acid, or metal alcoholate and mixtures thereof.
24. The device of claim 16 wherein the polymerization-promoting catalyst is a  
15 metal salt of a carboxylic acid.
25. The device of claim 16 wherein the polymerization-promoting catalyst is an organometallic.
26. The device of claim 16 wherein the polymerization-promoting catalyst is a tertiary amine.
- 20 27. The device of claim 16 wherein the isocyanate-containing prepolymer is 4,4'-methylene bis(cyclohexyl isocyanate), the polyol prepolymer is polyether polyol, the catalyst is organometallic, the reporter molecule is triarylmethane, and the UV stabilizer is benzotriazole.
28. The device of claim 16 wherein the isocyanate-containing prepolymer is  
25 4,4'-methylene bis(cyclohexyl isocyanate), the polyol prepolymer is polyether polyol, the catalyst is organometallic, the reporter molecule is fluoran, and the UV stabilizer is benzotriazole.
29. A device of claim 16 wherein the isocyanate-containing prepolymer is  
30 4,4'-methylene bis(cyclohexyl isocyanate), the polyol prepolymer is mixture containing polyether polyol, the catalyst is an organometallic, the reporter molecule is a triarylmethane lactone, and the UV stabilizer is a benzotriazole.

30. A method for fabricating a shaped dosimeter device comprising the steps of:

- a. mixing chemical components for forming a transparent or translucent polymer and one or more reporters;
- 5 b. receiving the mixture in a mold; and
- c. polymerizing said mixture to form the shaped dosimeter device.

31. The method of claim 30 when said transparent or translucent polymer is an optical plastic selected from the group consisting of acrylic, polystyrene, polyacetal, cyclic olefin copolymer, polycarbonate, epoxy resin, silicone, siloxane, 10 polymethylpentene, polyester, polysulfone, and polyurethane, copolymers and blends thereof.

32. The method of claim 30 wherein the one or more reporters are selected from the group consisting of spiropyrans, spirothiopyrans, spironaphthooxazines, spirobenzopyrans, spiroindolobenzopyrans, chromenes, 2,2,-dichlorchromenes, leuco 15 quinines, anthroquinone dyes, thiazine leuco dyes, oxazine leuco dyes, phenazine leuco dyes, monoarylmethane phthalides, diarylmethane phthalides, triarylmethane phthalides, monoheterocyclic phthalides, bisheterocyclic phthalides, alkenylphthalides, bridged phthalides, bisphthalides, diarylmethanes, triarylmethanes, triaryl methane lactones, fluoran leuco dyes, and tetrazolium salts.

20 33. The method of claim 30 wherein in step a. further comprising the step of mixing one or more activators selected from the group consisting of  $\alpha$ -hydroxy alkylphenones, acyl phosphine oxides, O-acyl- $\alpha$ -oximinoketones, organic peroxides, phenylgyoxylates, desylarylsulfides, phenyl phenacylsulfides, metallocene derivatives, transition-metal carbonyls,  $\alpha$ -amino acids, halogenated hydrocarbons, polyhalogenated 25 hydrocarbons, alkoxyamines, azoalkane derivatives, diazonium salts, diaryliodonium salts, triarylsulfonium salts, dialkylphenacylsulfonium salts, ferrocenium salts,  $\alpha$ -sulfonyloxyketones, and silyl benzyl ethers, benzoin ethyl ether; benzoin isopropyl ether; benzoin butyl ethers (isomeric) ; benzoin isobutyl ether; benzildimethyl ketal; 2,2-diethoxy-1,2-diphenylethanone; 1,1-diethoxyactophenone; 1,1-di(n-butoxy)actophenone; 30 1-hydroxy-cyclohexyl-phenyl ketone; 2-hydroxy-2-methyl-1-phenyl-propan-1-one; 1-[4-(2-hydroxyethoxy)phenyl]-2-hydroxy-2-methyl-propan-1-one; benzophenone; 2-methyl-

1-[4-(methylthio)phenyl]-2-morpholino-propane-1-one; 2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)-butan-1-one; 2,4,6-trimethylbenzoyl-diphenylphosphine oxide; 2,4,6-trimethylbenzoyl-phenylphosphinic ethyl ester; bis(2,4,6-trimethylbenzoyl)-phenylphosphine oxide; bis(2,6-dimethoxybenzoyl)-2,4,4-trimethylpentylphosphine oxide; 2,2,2-trichloro-1-[4-(1,1-dimethyl)phenyl]-ethanone; 2,2-dichloro-1-(4-phenoxyphenyl)-ethanone; 4,4'-bis(chloromethyl)benzophenone; phenyl tribromomethylsulfone; methyl benzoyl formate; 2,4,6-trimethylbenzophenone; 4-methylbenzophenone; 4-chlorobenzophenone; 4-(4-methylphenylthio)benzophenone; 3,3'-dimethyl-4-methoxybenzophenone; methyl 2-benzoylbenzoate; 4-phenylbenzophenone; 4,4'-bis(dimethylamino)benzophenone; 4,4'-bis(diethylamino)benzophenone; 2-chlorothioxanthone; 4-chlorothioxanthone; 2-isopropylthioxanthone; 4-isopropylthioxanthone; 2,4-dimethylthioxanthone; 2,4-diethoxythioxanthone; 1-chloro-4-propoxythioxanthone; benzil; 1,7,7-trimethyl-bicyclo[2.2.1]heptane-2,3-dione; 2-ethylanthraquinone; 4-benzoyl-N,N,N-trimethylbenzene methaminium chloride; 2-hydroxy-3-(4-benzoylphenoxy)-N,N,N-trimethyl-1-propaniminium chloride; 2-hydroxy-3-(3,4-dimethyl-9-oxo-9H-thioxanthon-2-yloxy)-N,N,N-trimethyl propaniminium chloride; 4-(13-acryloyl-1,4,7,10,13-pentaoxatridecyl)benzophenone; 4-benzoyl-N,N-dimethyl-N-[2-(1-oxo-2-propenyl)oxy]ethyl benzenemethaminium chloride; methyldiethanolamine; triethanolamine; ethyl 4-dimethylaminobenzoate; 2-n-butoxyethyl 4-(dimethylamino)benzoate; isoamyl 4-dimethylaminobenzoate; 2-(dimethylamino)ethyl benzoate; tetrachloroethane; carbon tetrachloride; chloroform; dichloromethane; methylene chloride; 1,4-dichloro-2-butene; 2,2'-azobis(isobutyronitrile); 4,4'-azobis(4-cyanovaleric acid); 1,1'-azobis(cyclohexanecarbonitrile); 2,2'-azobis(2-methylpropane), 1,1-dichloropropane; 1,2-dichloropropane; 1,3-dichloropropane; 2,4,5-trichloroimidazole; 2,2-dichloropropane; 1,2-dichlorobutane; 1,3-dichlorobutane; 1,4-dichlorobutane; 1,1,1-trichloroethane; 1,2,2-trichloroethane; 1,2,3-trichloropropane; 1,1,1,2-tetrachloroethane; 1,1,2,2-tetrachloroethane; bromoform; methylene bromide; dibromomethane; 1,1-dibromo-2,2-bis(chloromethyl)cyclopropane; 1,2-dibromobutane; 1,3-dibromobutane; 1,4-dibromobutane; 2,3-dibromobutane; 1,4-dibromo-2,3-butanedione; 1,4-dibromo-2-butene; 1-bromo-4-chlorobutane; 1-bromo-2-chloroethane; 1-bromo-6-chlorohexane;

bromochloromethane; 1-bromo-5-chloropentane; 1-bromo-3-chloropropane; 2-bromo-1-chloropropane; 1,1,2-tribromoethane; 2,4,5-tribromoimidazole; 1,2,3-tribromopropane; bromodichloromethane; chlorodibromomethane;  $\alpha$ -(trichloromethyl)benzyl acetate; diphenyliodonium hexafluorophosphate; 4-methylphenyl-4'-isobutryl iodonium hexafluorophosphate; and ferrocene.

34. The method of claim 30 wherein in step a. further comprising the step of mixing a UV stabilizer selected from the group consisting of benzophenones, phenolics, thiopropionates, trialkyl phosphites, triaryl phosphites, benzoates, benzotriazoles, cyanoacrylates, organonickel compounds, organozinc compounds, diphenyl acrylates, cinnamates, and hindered amines.

35. A method of claim 30 wherein the chemical components for forming a transparent or translucent polymer are one or more isocyanate-containing prepolymers and one or more polyol prepolymers in the presence of one or more polymerization-promoting catalysts.

36. A method of claim 30 wherein the isocyanate-containing prepolymer comprising 4,4'-methylene bis(cyclohexyl isocyanate) or 1,6-hexamethylene diisocyanate or a mixture thereof and the polyol prepolymer comprising one or more of polyether polyol, polycarbonate polyol, or polyester polyol.

37. A method of claim 30 wherein the polymerization-promoting catalyst is selected from the group consisting of tertiary amine, organometallic, metal salt of a carboxylic acid, or metal alcoholate and mixtures thereof.

38. A method for detecting radiation comprising;  
a. subjecting a shaped solid dosimeter to a radiation field, said dosimeter fabricated from a transparent or translucent polymer and one or more reporter molecules dispersed within said device, and

b. analyzing three dimensional data from said dosimeter exposed to said radiation field by evaluating optical properties of said dosimeters.

39. The method of claim 38 wherein the radiation is ionizing radiation.

40. The method of claim 38 wherein the radiation is x-ray radiation.

41. The method of claim 38 wherein the radiation is neutron radiation.

42. The method of claim 38 wherein spectrophotometric analysis is used in the step b.
43. The method of claim 38 wherein a tomographic process is used in step b.
44. The method of claim 43 wherein tomographic process comprises the steps
- 5 of;
- d. illuminating said dosimeter with a light source;
- e. detecting light from said dosimeter; and
- f. processing said detected light to construct a three dimensional image.
45. The method of claim 44 further comprising the step rotating said
- 10 dosimeter and repeating steps d, e, and f.
46. The method of claim 43 further comprising the step of:
- c. calculating an amount and distribution of radiation received by the dosimeter from said analyzed three dimensional data.
47. The method of claim 44 wherein an absolute dose is calculated in said
- 15 step c.
48. The method of claim 38 wherein the radiation emits from a radionuclide.
49. The method of claim 48 wherein the radionuclide is selected from the group consisting of radioactive isotopes of iodine, strontium, samarium, yttrium, ruthenium, palladium, cobalt and iridium.
- 20 50. A system for detecting radiation comprising:
- means for subjecting a shaped solid dosimeter to a radiation field said dosimeter is fabricated from a transparent or translucent polymer and one or more reporter molecules dispersed within said device;
- means for analyzing three dimensional data from said dosimeter exposed to said
- 25 radiation field by evaluating optical properties of said dosimeter.
51. The system of claim 50 wherein the radiation is ionizing radiation.
52. The system of claim 50 wherein the radiation is x-ray radiation.
53. The system of claim 50 wherein the radiation is neutron radiation.
54. The system of claim 50 wherein said means for analyzing comprises
- 30 spectrophotometric analysis.



55. The system of claim 54 when said means for analyzing comprises a tomographic process.

56. The system of claim 55 wherein said tomographic process comprises;  
means for illuminating said dosimeter with a light source;  
5 means for detecting light from said dosimeter; and  
means for processing said detected light to construct a three dimensional image.

57. The system of claim 56 wherein said means for detecting comprises a Charged Coupled Device (CCD), Complementary Metal-Oxide Semiconductor (CMOS) sensor camera or digital camera.

10 58. The system of claim 50 further comprising means for rotating said dosimeter.

59. The system of claim 50 further comprising means for calculating an amount and distribution of radiation received by the dosimeter from said analyzed three dimensional data.

15 60. The system of claim 57 wherein said means for calculating calculates an absolute dose.

61. The system of claim 50 wherein the radiation emits from a radionuclide.

62. The system of claim 62 wherein the radionuclide is selected from the group consisting of radioactive isotopes of iodine, strontium, samarium, yttrium,  
20 ruthenium, palladium, cobalt, and iridium.

63. The system of claim 50 further comprising means for erasing said three dimensional data from said dosimeter.

64. A method in pretreatment planning in Conformal Radiation Therapy using said system of claim 50.

25 65. A method of pretreatment planning in Intensity Modulated Radiation Therapy (IMRT) using said system of claim 50.

*66 65.* The system of claim 50 further comprising means for erasing said three dimensional data from said dosimeter.

*67 66.* A method of pretreatment planning in Boron Neutron Capture Therapy  
30 (BCNT) comprising the step of using the system of claim 50.

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68 67. A method of pretreatment planning in Brachytherapy comprising the step of using the system of claim 50.

69 68. A method of pretreatment planning in Permanent Seed Brachytherapy comprising the step of using the system of claim 50.

5 70 69. A method of pretreatment planning in High Dose Rate Temporary (HDR) Brachytherapy comprising the step of using the system of claim 50.

71 70. A method of pretreatment planning in Vascular Brachytherapy comprising the step of using the system of claim 50.

10 72 71. A method of pretreatment planning in HDR Brachytherapy of breast cancer, prostate cancer, or lung cancer comprising the step of using the system of claim 50.